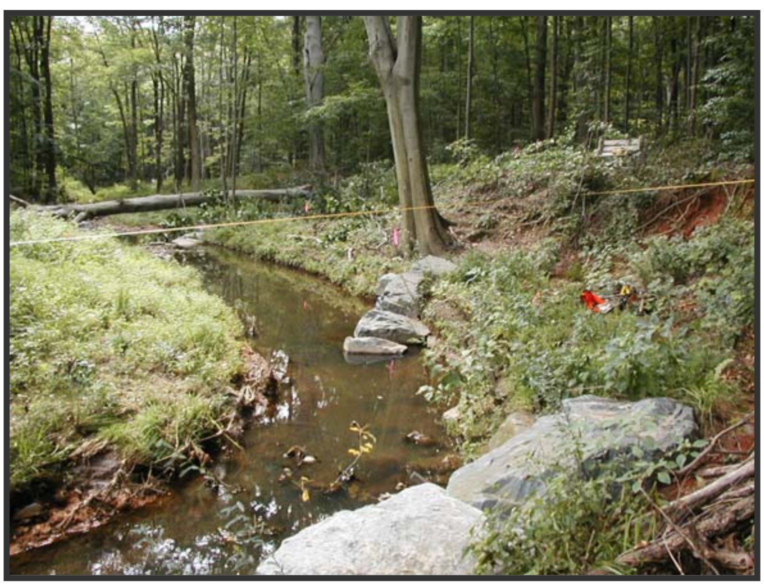
# Mt. Royal Tributary Restoration Monitoring Report



Prepared for:
The Harford County Department of Public Works

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Prepared by:
KCI Technologies Inc.
10 North Park Drive
Hunt Valley, MD
21030

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## 1.0 INTRODUCTION

Harford County has recently completed the construction of a 650 linear foot stream restoration project within an unnamed tributary of Swan Creek referred to as the Mount Royal tributary. The project area is located in Aberdeen in southeastern Harford County, Maryland. The project is located south of the Aberdeen Thruway (MD 22) and east of Mount Royal Avenue, and originates immediately downstream and to the east of a new wetland/water quality enhancement storm water management (SWM) facility that was constructed concurrently with the stream restoration project. The SWM facility is situated at the southwest corner of the intersection of Mount Royal Avenue and MD 22. (See Figure 1 – Site Vicinity Map)

This report presents the methods used to monitor the success of the stream restoration project, as well as the results, a discussion, and the conclusions from the Year One post-construction monitoring effort. The report will serve as the baseline conditions report to which subsequent yearly monitoring events will be compared. Reports for the yearly monitoring events that will follow the Year One monitoring will not repeat the introduction and methodologies sections, but instead will consist of Supplements that include only the results, discussion and conclusions sections for those years, which can then be added to this monitoring report.

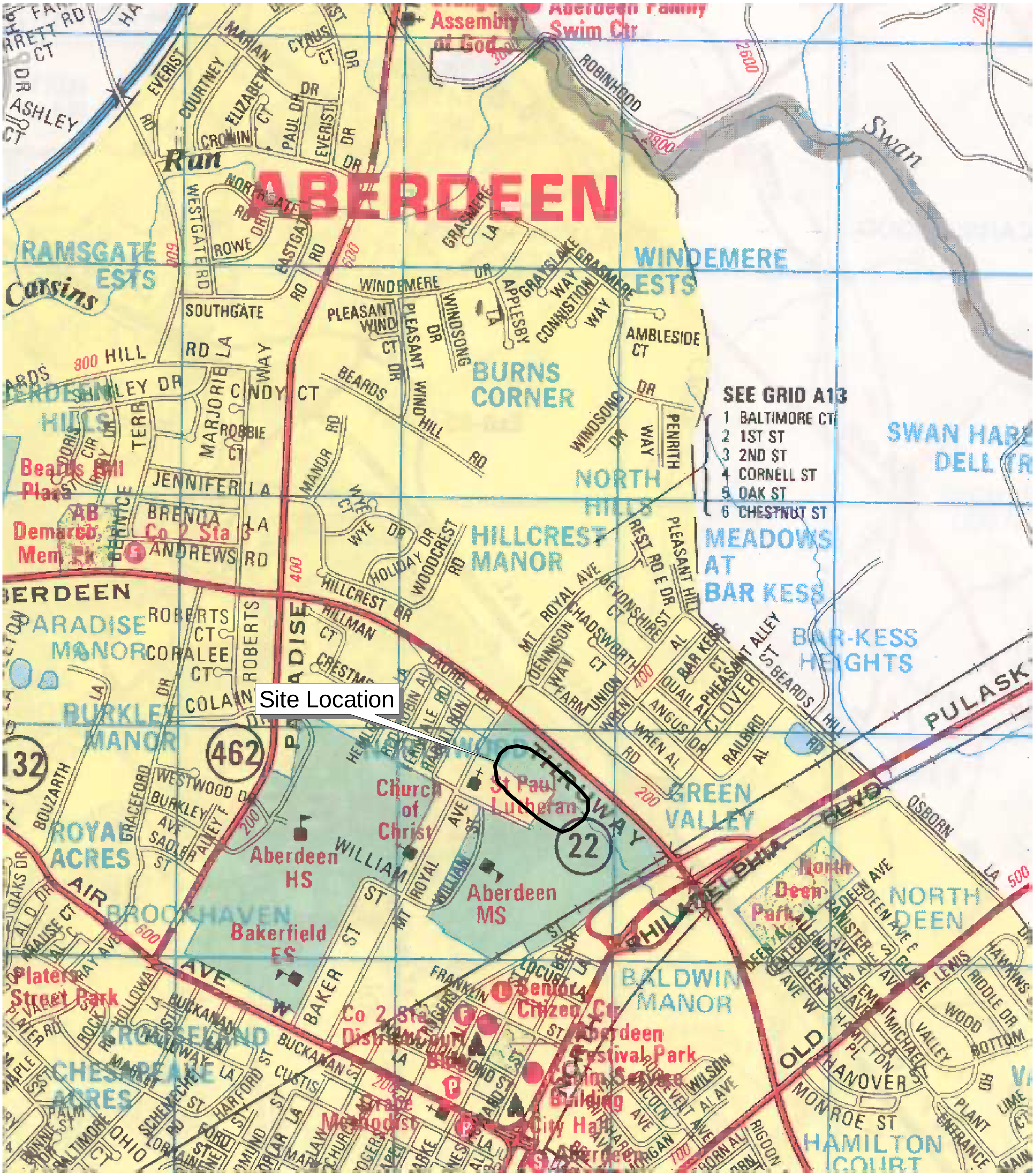
### 1.1 DESCRIPTION OF MITIGATION EFFORTS

The 650 linear foot project was constructed as mitigation for the placement of the new upstream SWM facility. The main purpose of the project was to reduce lateral channel movement, downstream sedimentation, and stream downcutting. To improve the conditions, various in-stream structures, including cross vane weirs, boulder spurs, and single and double-stacked coir rolls were installed. In addition, native trees, shrubs and live stakes were planted throughout the entire project site, temporary and permanent seed was placed and erosion control fabric was installed. Refer to Appendix A for photographs depicting the overall site conditions and restoration applications.

### 1.2 OVERVIEW OF MONITORING ACTIVITIES

Monitoring protocols for the Mount Royal tributary site were developed in order to evaluate the success and stability of the restored stream channel. These protocols involve fluvial geomorphologic assessments, inspections of installed channel stabilization techniques, and vegetative stabilization inspections, which are performed annually during baseflow stream conditions. The monitoring program, as detailed briefly below and in greater detail in the methodologies section, is conducted on an annual basis for a minimum 3-year monitoring period, beginning in 2004. Following the conclusion of this monitoring period, the County will determine if additional monitoring or any remediation efforts will be needed.

Fluvial geomorphologic monitoring is conducted in order to evaluate the bed and bank stability and the establishment of riffle/pool sequences. Four monumented channel cross-sections were established during baseline monitoring at various critical locations along the restored tributary. Each section is measured annually during baseflow conditions to evaluate channel stability. Topographic survey of the entire restored stream reach was completed during baseline monitoring for comparison to as-built and/or final design plans in order to assess changes to the channel and floodplain. Subsequent annual monitoring events do not include completion of full topographic survey of the channel. However, during the topographic survey, a stream profile was surveyed to delineate the bed features along the thalweg or low flow line of the stream, and a stream profile




# Mount Royal Tributary Restoration
# Site Vicinity Map

Harford County, Maryland
ADC Map 20 Grid C-12
ADC of Alexandria, 2000

N
Not to Scale

survey to track changes in slope and bed features is conducted annually. Pebble counts are conducted at two riffles and one deposition bar annually. Bed and bank pins installed during baseline monitoring conditions are also monitored annually to assess general bank stability.

Cursory inspections are conducted annually for each of the installed channel stabilization techniques, including both in-stream structures and non-vegetative bank stabilization techniques. Vegetation inspections are also conducted annually and include a cursory assessment of the success of the installed bioengineering materials (live stakes) and other riparian vegetation, as well as an assessment of volunteer species that are becoming established.

Because the results section of this report covers the Year One baseline conditions monitoring effort, a brief explanation is provided comparing the intended design features to the post-construction monitoring results.

### 1.3 GOALS AND OBJECTIVES

As detailed above, the Mount Royal tributary restoration project involved the use of various in-stream structures, including cross vane weirs, boulder spurs, and coir rolls, as well as bioengineering, riparian plantings, and permanent seed with erosion control fabric. As a goal of this project, Harford County expects improved pool/riffle formation, reduced embeddedness and sedimentation, and overall improved aquatic and riparian habitat quality within the Mount Royal tributary.

## 2.0 METHODOLOGIES

### 2.1 FLUVIAL GEOMORPHIC ASSESSMENT MATERIALS AND METHODS

The fluvial geomorphic assessment is conducted to quantify basic stream characteristics including bed and bank stability as well as riffle/pool sequences. Full topographic survey of the restored stream reach, and cross-sectional and longitudinal profile surveys are completed to establish baseline conditions, compare the Year One post-construction monitoring results to the proposed design/as-built plans provided by the County's original design consultant, Greenhorne & O'Mara, Inc. (G&O) and ultimately to compare any changes in channel geometry and slope that occurs over subsequent annual monitoring events. Pebble counts are performed to characterize channel substrate and to estimate channel roughness. Bank and bed pins are monitored to determine rates of potential bank and channel bed erosion or aggradation. Detailed methods are described below.

#### *2.1.1 Topographic, Longitudinal Profile and Cross-sectional Surveys*

Full topographic survey of the project site was completed during the Year One monitoring effort to develop mapping of the baseline post-construction conditions. Features picked up during this survey include elevation shots to develop contours at one-foot intervals, elevations along the field identified location of the centerline of flow or thalweg of the stream, the SWM facility outfall structure, the locations of installed in-stream structures, and pool/bar formations. A longitudinal profile of the stream was developed for the baseline conditions based on the thalweg survey.

This topographic survey serves as the baseline field conditions for comparison during annual post-construction monitoring efforts. The plotted longitudinal profile also serves as the baseline for comparison during subsequent years and is used to track changes that occur in the bed structure sequences. Because digital files of the original design plans or as-built plans completed by G&O were unavailable to KCI, no direct comparisons could be made between those surveys and the baseline condition surveys. Instead, visual comparisons are made and generally described in the results of this Year One monitoring report. It should be noted that stationing along the channel thalweg, as surveyed by KCI, differs from stationing on the as-built plans. The stationing shown on the design/as-built plans appears to be based on a centerline of construction, rather than on the proposed thalweg of the channel.

In order to establish locations where fluvial geomorphic characteristics of the channel could be measured and compared from one year to the next to assess bed and bank stability, permanent cross-sections were established at four (4) locations along the channel; two along riffles and two along pools. Each cross-section was monumented on both sides of the channel with a carriage bolt set into concrete in a PVC pipe cast. The monument locations and elevations were surveyed and added to the topographic base mapping. Cross-sections are field surveyed annually at each of the following stations using a laser level, calibrated stadia rod, and measuring tape.

| | |
|---|---|
| Section 1 - Station 0+45 | Section 3 - Station 4+45 |
| Section 2 - Station 3+35 | Section 4 - Station 5+70 |

Surveyed cross-sections are plotted and each of the annual monitoring years are overlain and compared to the baseline condition cross-sectional measurements. The focus of these evaluations is on bankfull width, mean depth, width/depth ratios, and overall bank stability.

For the purpose of this report, bankfull elevations were selected based upon apparent top of bank design features. These elevations were established at topographical breaks in the constructed geometry that appear to represent bankfull features. For future monitoring events, these elevations will be utilized as the set bankfull elevations at each section to generate hydraulic geometry values that are directly comparable between each monitoring effort.

### *2.1.2 Wolman Pebble Counts*

Channel substrate composition is an important aspect of a stream's geomorphic character. Sediment size provides insight into channel roughness and flow determination using incipient motion analysis such as the Shields Diagram. Generally, the most efficient method to determine sediment size of the channel bed and banks is the Wolman pebble count (Leopold et al., 1964).

The pebble count procedure used for this post-construction monitoring effort was adapted from *Stream Channel Reference Sites: An Illustrated Guide to Field Technique* (Harrelson et al, 1994). Three sites were chosen for sampling and analysis: two are located in riffles and the final count is situated at a bar location. A minimum of 100-particles is obtained to ensure a valid count. Particles are then tallied using Wentworth size classes, in which the size doubles with each class (<2, 2, 4, 8, 16, 32, etc.). Sampling at transects begins at a randomly selected point. The intermediate axis (neither the longest nor shortest of three mutually perpendicular sides) of each collected particle is measured. Embedded particles or those too large to be moved in place are measured at the smaller of the two exposed axes. The sampler moves upstream or downstream randomly to take a sample total of at least 100 particles. After counts and tallies are completed, the data is plotted by size class and frequency on log-normal paper.

### *2.1.3 General Bank & Bed Stability (Bank Pins and Bed Pins)*

To monitor channel adjustments, KCI installed bank and bed (toe) pins at three of the four permanent cross-section locations. Pins were not installed in the remaining cross section because this area did not show any sign of erosion or instability, and because the structure on the outer meander bend did not allow for placement. Three-foot pins consisting of rebar were hammered into the top and toe of the bank until approximately one-inch was exposed above the surface. Following installation the offsets for each bank and bed pin were measured, beginning from the right monument (looking upstream/up-station along the survey baseline) at each of these cross-sections. Two pins were installed in a riffle at the outer bank of a meander in the stream, one at the top and one at the toe of the bank. Four pins were placed in a straight riffle section, two at the top and toe of each bank. The last pins were installed at a pool meander in the top and toe of the outer bank. Locations and offsets for the pins are listed below:

Station 0+45 – Meander Bend - Right Bank
Offsets 0+09 Bank Pin
0+14.8 Bed Pin

Station 3+35 – Riffle
Offsets 0+19 Bank Pin
0+22 Bed Pin
0+37.7 Bed Pin
0+45.1 Bank Pin

Station 4+45 – Meander Bend – Left Bank
Offsets 0+49 Bed Pin
0+52 Bank Pin

The exposed length of each pin was measured during Year One monitoring efforts then pins are surveyed annually to assess bed and bank erosion. This information is useful in determining if installed stream features or other circumstances occurring within the restored stream or its watershed are resulting in any new channel degradation, bank erosion or channel accretion.

## 2.2 CHANNEL STABILIZATION TECHNIQUE INSPECTIONS

A cursory visual assessment is conducted for each of the installed channel stabilization techniques, including both in-stream structures (cross vane weirs, boulder spurs, and boulder spurs with grade control) and non-vegetative bank stabilization techniques (single/double-stacked coir rolls and erosion control fabric). Evidence of movement within the structure, excessive scour, undercutting, erosion, or other type of failure of the technique is photographed and notes are recorded as to the degree and extent of the problem. No formal measurements of these structures/techniques are conducted following the baseline condition monitoring.

## 2.3 VEGETATIVE STABILIZATION TECHNIQUE INSPECTIONS

Informal visual inspections are conducted to generally assess the establishment and survivability of vegetative stabilization techniques along each 50-foot length of the stream channel. The first item evaluated is the overall percentage of areal vegetative cover (i.e., both installed materials and volunteer species) that has become established and is providing functionality along the banks. Functionality is defined as evidence of root growth that is maintaining the integrity of the stream bank. Areas where vegetative establishment within the project limits is sparse or non-existent are areas that may become prone to erosion. These areas are evidenced from a lowering of this percentage.

The second item assessed is the percentage of plant survivability of both the installed vegetative stabilization techniques (i.e., live stakes, riparian plantings, and permanent seed) and any volunteer species establishing within the above areal coverage. Survivability is defined as evidence of growth leading to the development of healthy leaves and roots. Because the exact locations of the installed plant materials were not surveyed in as part of the as-built plans, have not been marked/flagged, and are not always easily discernible in the field, formal determinations regarding plant survivability of only the installed vegetation have not been performed.

During the above inspections, the general health or any other apparent issues concerning the vegetation is noted. Areas where vegetative stabilization of the banks is failing significantly or the vegetation is showing signs of stress, disease, pest/predation problems, or poor survivability are also noted and their approximate location is recorded. The presence, location and extent of any invasive species becoming established that could potentially displace native plantings are also recorded.

# 3.0 MONITORING YEAR 1: RESULTS AND DISCUSSION

## 3.1 FLUVIAL GEOMORPHIC ASSESSMENT

### *3.1.1 Topographic, Longitudinal Profile and Cross-sectional Surveys*

The topographic survey of the project study area was completed by KCI in July 2004. The mapping developed from this survey serves as baseline post-construction condition mapping to compare field conditions measured and inspected during future annual monitoring events. As mentioned above, the SWM facility outfall structure and the locations of each of the installed in-stream structures (cross vane weirs, boulder spurs, and boulder spurs with grade control) were also surveyed and included on the base mapping, as were the locations of significant pools and bar features. The locations of the single and double-stacked coir rolls, a remnant oxbow and wetland area, and a downed 24” DBH American beech tree were later added based on field measurements and visual estimates of their locations, as determined during a field walk by KCI’s Environmental Scientists in November 2004. (Refer to Appendix B for baseline condition topographic mapping)

The topographic survey conducted by KCI is generally consistent with the As-Built Survey performed by G&O in 2002, although the location of the centerline of flow or thalweg differs somewhat from the centerline on the as-builts. This is in part due to the centerline on the as-builts apparently associated with a baseline for construction of the channel rather than the thalweg of the stream. However, additional differences are likely due to the channel adjusting as it moves sediment, creates new bars, and attempts to reach equilibrium during base and flood conditions within the restored and stabilized banks.

The longitudinal profile data was analyzed to estimate the slope of the restored channel. The slope was determined by subtracting the elevation at the top of a riffle at the downstream extent of the project from the elevation at the top of a riffle at the upstream end of the project, then dividing this number by the total length of the channel between these two points, as measured along the thalweg of the stream. The measured slope, as indicated in Table 3-1, will be compared to subsequent annual monitoring data to track potential changes in the overall channel bed slope. In addition, the surveyed profile during these annual events will be plotted, overlain and compared to the baseline condition profile (Appendix C) in order to assess changes occurring in the bed structure.

***Table 3-1 Channel Bed Slopes***

| Event | Bed Slope |
|---|---|
| Baseline 2004 | 0.005017 |

As described above, cross-sectional surveys were analyzed at each of the four permanent monitoring locations to determine bankfull width, mean depth, the width/depth ratio, and overall cross-sectional area during baseline conditions. Results of the cross-sectional measurements are included in Table 3-2 and graphical depictions of each section are presented in Appendix D.

***Table 3-2 Results of Cross-Sectional Survey Analysis***

| Date Performed | Bankfull Width (ft) | Mean Depth (ft) | Width/ Depth Ratio | Cross-sectional Area ($ft^2$) |
|---|---|---|---|---|
| **Section 1 - Station 0+45 – Riffle** | | | | |
| July 26, 2004 | 33.9 | 1.44 | 23.54 | 47.3 |
| **Section 2 - Station 3+35 – Riffle** | | | | |
| July 26, 2004 | 24.75 | 1.20 | 20.69 | 29.6 |
| **Section 3 - Station 4+45 – Pool** | | | | |
| July 26, 2004 | 13.08 | 1.87 | 6.98 | 24.5 |
| **Section 4 - Station 5+70 – Pool** | | | | |
| July 26, 2004 | 23.07 | 1.86 | 12.38 | 43.0 |

As the recommended bankfull width, mean depth, width/depth ratio and cross-sectional area from the original design were unavailable to compare to the baseline post-construction monitoring measurements above, it is being assumed that the constructed stream measurements fall within a reasonable range of tolerances to meet the intent of the design. This assumption is being made due to the fact that the baseline condition topography is very similar to the as-built plans and because the channel appears to be stable and functioning as initially intended. During future annual investigations, cross-sections will be measured and compared to the above baseline information and plotted sections to determine changes that may be occurring that may indicate instability in the channel.

### *3.1.2 Wolman Pebble Counts*

The results of the pebble count data collected during the Year One monitoring effort indicate that normal sediment transport characteristics are developing in the restored system. The average for the $D_{50}$ for riffles was in the coarse gravels range and the $D_{84}$ was in the small cobble range. The average $D_{50}$ associated with the bar was in the medium gravel range and the $D_{84}$ was in the course gravels range. As indicated by the data, larger particles are found in the riffle areas, which is characteristic of a natural system. Fluctuations are expected to occur in particle size throughout each monitoring period, and these fluctuations would likely be the result of the different sediment transport capabilities of the various types of flow events that occur over a particular period in time. These natural fluctuations do not necessarily indicate imbalances in the stream. It is important to continue to monitor particle size distributions of riffles to determine if sedimentation is occurring that could negatively affect macroinvertebrate habitat conditions. Particle size distribution charts are included in Appendix E. The resulting values are included in Table 3-3 below.

***Table 3-3 Result of Particle Size Analysis - Riffles/Bar***

| **Station Identity** | **Mean Particle Size (mm)** | |
|---|---|---|
| | **$D_{50}$** | **$D_{84}$** |
| 2+50 Riffle-July 2004 | 32.9 | 72.9 |
| 3+25 Riffle-July 2004 | 42.8 | 80.0 |
| **Average Riffle- July 2004** | **37.9** | **76.5** |
| 0+45 Bar July 2004 | 11.1 | 22.4 |
| **Average Pool- July 2004** | **11.1** | **22.4** |

### *3.1.3 <u>General Bank and Bed Stability</u>*

During the baseline condition monitoring, bed and bank pins were established and the exposed length of each pin was measured. The bank and toe pins will be surveyed each year and compared to the baseline and previous years data. The exposed lengths of each pin are summarized in Tables 3-4 through 3-6.

***Table 3-4 Station 0+45 Riffle***

| Location Along Section | Bank/ Toe Pin | Elevation of Pin (Level of Exposure/Deposition) Feet (feet) |
|---|---|---|
| | | 7/26/04 |
| 0+09 | Bank | -0.07 |
| 0+14.8 | Bed | -0.07 |

***Table 3-5 Station 3+35 Riffle***

| Location Along Section | Bank/ Toe Pin | Elevation of Pin (Level of Exposure/Deposition) Feet (feet) |
|---|---|---|
| | | 7/26/04 |
| 0+19.0 | Bank | -0.14 |
| 0+22.0 | Bed | -0.10 |
| 0+37.7 | Bed | -0.11 |
| 0+45.1 | Bank | -0.11 |

***Table 3-6 Station 4+45 Pool***

| Location Along Section | Bank/ Toe Pin | Elevation of Pin (Level of Exposure/Deposition) Feet (feet) |
|---|---|---|
| | | 7/26/04 |
| 0+49 | Bed | -0.14 |
| 0+52 | Bank | -0.14 |

Because this is the first post-construction assessment, no data comparison is included in this report. Subsequent monitoring data will be compared to these baseline conditions to evaluate erosion and depositional trends associated with the restoration project. Negative values for the measurements indicate the length of pin exposed, while positive values indicate the amount of deposition on top of the pin.

### 3.2 CHANNEL STABILIZATION TECHNIQUES

Channel stabilization techniques were inspected throughout the restored stream reach in July and also in early November 2004, following receipt of the full topographic survey. The topographic survey included the locations of visible portions of each of the cross vane weirs, boulder spurs, and boulder spurs with grade control. KCI's Environmental Scientists walked the channel to confirm the location of each structure and to assess their functionality. The approximate locations of each structure and a description of their functionality, as assessed during the Year One monitoring efforts, is included in Table 3-7 below.

***Table 3-7 Channel Stabilization Structures – July & November 2004***

| Station | Structure Type | Comments |
|---|---|---|
| 0+25 LT | Boulder Spur | Functioning properly to protect left bank – No erosion evident. Significant in-stream portion of spur covered by bar feature. |
| 0+50 LT | Boulder Spur | Functioning properly to protect left bank – No erosion evident. Significant in-stream portion of spur covered by bar feature. |
| 0+60 RT | Small Boulder Spur | Not shown on as-built plans – May be additional placed stones or a portion of the grade control feature in the boulder spur at Sta. 0+70. |
| 0+70 | Boulder Spur w/ Grade Control | Functioning properly to protect channel grade and banks – No erosion evident and good pool formation on downstream side. |
| 0+75 RT | Boulder Spur | Functioning properly to protect right bank – No erosion evident. |
| 0+80 RT | Boulder Spur | Functioning properly to protect right bank – No erosion evident. |
| 3+70 | Cross Vane Weir | Functioning properly to protect channel grade and banks – minor pool formation on downstream side. |
| 4+15 LT | Boulder Spur | Functioning properly to protect left bank – No erosion evident. |
| 4+50 LT | Boulder Spur | Functioning properly to protect left bank – No erosion evident. |
| 4+60 LT | Boulder Spur | Functioning properly to protect left bank – No erosion evident. |
| 4+90 | Boulder Spur w/ Grade Control | Functioning properly to protect channel grade and banks – No erosion evident and minor pool formation on downstream side. |
| 5+10 RT | Boulder Spur | Functioning properly to protect right bank – No erosion evident. |
| 5+25 RT | Boulder Spur | Functioning properly to protect right bank – No erosion evident. |
| 5+50 LT | Boulder Spur | Functioning properly to protect left bank – No erosion evident. |
| 5+66 | Cross Vane Weir | Functioning properly to protect channel grade and banks – minor pool formation on downstream side and larger pool on upstream side. |

As mentioned previously, during the site walk, the locations for both the single and double-stacked coir rolls were also identified and marked on a plan sheet based on field measurements and visual estimates of their locations. Each stretch of coir roll was inspected in order to assess whether they were functioning and installed properly or if there were any evident problems.

While vegetative establishment on many of the rolls, and especially those in well-shaded areas, was somewhat sporadic, it appeared that installation was performed properly on all of the rolls and they appeared to be functioning properly in stabilizing the banks. Structurally, there was no major shifting in any of the rolls and only a few minor scour areas/undercuts were evident along the toe in several locations where the thalweg of the stream flows immediately adjacent to the coir rolls, but these undercuts are not threatening their stability and they likely provide a good habitat area for small fish.

Erosion control fabric, where evident along the channel banks, was also inspected during this site walk. There were no major areas identified where erosion control fabric was failing.

## 3.3 VEGETATIVE STABILIZATION TECHNIQUES

Vegetative stabilization techniques were inspected along 50 linear foot lengths of the restored channel reach in July 2004. Data collected for the Year One baseline condition monitoring efforts is listed in Tables 3-8 and 3-9 below. Relevant comments regarding the vegetation establishment and survivability are also included in the tables and additional information assessed concerning the overall health of the vegetation, or any other evident problems within the reach are described in the discussion below.

***Table 3-8 Left Bank – July 2004***

| Right Bank Station | Percent Areal Vegetation Coverage on Banks | Percent Survivability of Vegetative Cover | Comments |
|---|---|---|---|
| 0+00 to 0+50 | 50 | 100 | Deposition evident in floodplain |
| 0+50 to 1+00 | 85 | 90 | |
| 1+00 to 1+50 | 100 | 95 | Live stakes not well established |
| 1+50 to 2+00 | 70 | 80 | Live stakes not well established |
| 2+00 to 2+50 | 95 | 95 | Live stakes not well established |
| 2+50 to 3+00 | 95 | 95 | Live stakes not well established |
| 3+00 to 3+50 | 100 | 100 | |
| 3+50 to 4+00 | 85 | 70 | |
| 4+00 to 4+50 | 60 | 100 | Exposed bank from oxbow beginning to heal over |
| 4+50 to 5+00 | 65 | 95 | Exposed bank from oxbow beginning to heal over |
| 5+00 to 5+50 | 100 | 100 | Well vegetated floodplain/banks |
| 5+50 to Structure | 100 | 100 | Well vegetated floodplain/banks |
| **Averages** | **84%** | **93%** | |

*Table 3-9 Right Bank – July 2004*

| Left Bank Station | Percent Areal Vegetation Coverage on Banks | Percent Survivability of Vegetative Cover | Comments |
|---|---|---|---|
| 0+00 to 0+50 | 75 | 95 | Deposition evident in floodplain |
| 0+50 to 1+00 | 85 | 95 | |
| 1+00 to 1+50 | 95 | 100 | |
| 1+50 to 2+00 | 80 | 80 | Live stakes not well established |
| 2+00 to 2+50 | 90 | 90 | Floodplain/banks well vegetated with various grasses |
| 2+50 to 3+00 | 90 | 90 | Floodplain/banks well vegetated with various grasses |
| 3+00 to 3+50 | 95 | 95 | Floodplain/banks well vegetated with various grasses |
| 3+50 to 4+00 | 100 | 100 | Floodplain/banks well vegetated with various grasses |
| 4+00 to 4+50 | 95 | 95 | 2 live stakes apparently dead/well vegetated |
| 4+50 to 5+00 | 95 | 95 | 4 live stakes apparently dead/well vegetated |
| 5+00 to 5+50 | 95 | 95 | 2 live stakes apparently dead/well vegetated |
| 5+50 to Structure | 100 | 100 | Floodplain/banks well vegetated with various grasses |
| **Averages** | **91%** | **94%** | |

In general, the banks appear to be stable and well vegetated although there are a few minor areas where vegetative establishment and/or plant survivability is less than optimal. The areal cover on both the left and right banks throughout the restored reach is excellent, with the coverage along the right bank (91%) slightly better than along the left bank (84%). Several reaches were identified that exhibited less than 70% areal vegetative cover that could potentially become problem areas along the channel if volunteer species do not begin to establish over time. Generally though, even in these areas, the vegetation that was present appeared to be healthy and functioning well in stabilizing the banks.

Typically, bare areas along a restored streambank may be the result of any number of items, including, but not limited to: seed washing away from beneath installed erosion control fabric before becoming rooted into the soil; improper installation of seed/plants or erosion control fabric; poor quality, damaged or non-viable seed/plant materials; excessive deposition covering the vegetation; erosive velocities removing the vegetation; or, an indication of areas where the installed stream features are not functioning as intended by the designer. At this time, it is difficult to determine the causes for the lack of vegetation in areas where areal cover was lower, but it also does not appear to be a significant enough problem that it would require any immediate attention. It should be noted that the majority of the restored stream channel is located in a relatively dense forest, so shading effects may also be delaying some of these areas from becoming well established with vegetation.

Survivability of vegetative cover along both the left and right banks is also excellent, based on the percentages indicated in the tables above which take into account all forms of vegetation, including permanently seeded areas, live stakes, and other riparian herbaceous, shrub and tree vegetation. Survival along the right bank (94%) is very slightly better than along the left bank (93%).

When considering just the bioengineering materials installed as part of the restoration effort, in general, the live stakes appeared to be in relatively satisfactory condition throughout much of the reach. In the areas between Stations 1+00 to 3+00 on the left bank and from Stations 1+50 to 2+00 on the right bank, live stake establishment was not as successful as in many other areas. In addition, some of the live stakes located between Stations 4+00 to 5+50 appear to have minimal growth. Success of live staking is dependent on many factors including: viability of the planted materials (live stakes dry out quickly if not kept in cool moist areas); the season in which they are harvested and installed (must be dormant plants); the degree of shading and shade tolerance of the plants; the procedures used during installation (proper backfilling of holes and cutting off of damaged ends), and the amount of water delivered to root zones, just to name a few. The cause for the minimal success in these particular areas could not be ascertained from the inspections. Further monitoring will be done during subsequent years to track the development of the live stakes, spread of materials from successful live stakes, and to determine if further plantings will be necessary to fully stabilize the banks.

A downed American beech tree is located near station 3+45, immediately upstream from one of the monumented cross-sections (Section 2), but the tree does not appear to inhibit baseflow. At the present time, it appears that no erosion is occurring during higher flows around or near the tree. An area of concern that should be monitored includes the left bank between stations 4+00 and 5+00 in the area labeled as a remnant oxbow (see Appendix A, Photo 12). Vegetation is sparse in this area and roots are exposed. Subsequent annual monitoring will be performed to track potential problems in these areas. The cross-section located at Station 4+45 will provide significant monitoring data to substantiate any changes that occur to the bank.

Overall, the floodplain and banks are well vegetated with various grasses and other herbaceous cover, and the live stakes and other riparian vegetation appear to be beginning to provide strong rooting for long-term stabilization of the banks. Vegetation growth within coir rolls, as discussed above, appears to be minimal though. However, the logs provide bank stabilization and appear to be preventing erosion from occurring on or around the banks. As additional sediment collects on the rolls during high flow events and the surrounding seed bank becomes established, it is likely that vegetative establishment will occur on the coir rolls.

## 4.0 CONCLUSION

The Harford County Department of Public Works, Water Resources Engineering Division requested KCI to perform stream monitoring to fulfill mitigation commitments associated with the construction of a wetland/water quality enhancement storm water management (SWM) basin located at the headwaters of the Mt. Royal Tributary. Mitigation efforts involved both bank and bed stabilization, and included the construction of cross vane weirs, boulder spurs, boulder spurs with grade control, single/double-stacked coir rolls, and the revegetation and stabilization of banks with live stakes, seed and erosion control fabric along the 650 linear foot restoration project.

To adequately assess the success of the project, a monitoring plan was developed that involves fluvial geomorphic, structure stability, and vegetation monitoring. To date, the fluvial geomorphic monitoring results suggest that the site is stable. Minor fluctuations within the channel bed are occurring as the reach attempts to reach equilibrium during both base and flood conditions. However, these changes are considered within the normal range of channel adjustment. As detailed previously, the 2004 monitored bankfull width, mean depth, width/depth ratio and cross-sectional area could not be compared to the original design because the design data were unavailable. However, it is assumed that the constructed stream measurements fall within a reasonable range of tolerances to meet the intent of the design because the baseline condition topography is very similar to the as-built plans and because the channel appears to be stable and functioning as initially intended.

Based on visual field observations, all installed structures are functioning in accordance with their associated design goals and objectives, and are providing bank protection, grade control, and habitat creation. Sediment deposition is occurring on several of the downstream structures and will be evaluated during future monitoring events. However, the deposition does not seem to be influencing the functionality of the structure, or the stability of the channel. In addition to the installed cross vane weirs, boulder spurs, and boulder spurs with grade control, the coir fiber rolls appear to be providing both bank stabilization and habitat.

In general, the banks appear to be stable and well vegetated although there are a few minor areas where vegetative establishment and/or plant survivability is less than optimal. Several reaches were identified that exhibited less than 70% areal vegetative cover and will be evaluated during subsequent monitoring efforts. Generally though, even in these areas, the vegetation that was present appeared to be healthy and functioning well in stabilizing the banks.

Based on the Year One monitoring efforts, it appears that the goals of the project, including improved pool/riffle formation, reduced embeddedness and sedimentation, and overall improved aquatic and riparian habitat quality are being achieved. Installed structures are providing bed and bank stabilization and habitat creation. In addition, vegetation, for the most part, is becoming established and is healthy.

However, because this is the first year of post-construction monitoring, conditions could change based on vegetation growth, sediment transport, and overall bank stability, as well as potential major flooding or catastrophic events. Subsequent monitoring will occur over a minimum of the next 2 years to track the stability of the restored stream and any changes that occur within the channel. Post-construction monitoring reports for subsequent monitoring years will be prepared and submitted yearly at the end of each year. The reports will only include the data collected, results and discussion section that compare the yearly results to the baseline information and previous years monitoring events, and a conclusions section summarizing whether or not the stream restoration project is continuing to meet the project goals.

## 5.0 REFERENCES

Harrelson, C.C., Rawlins, C.L. and J.P. Potyondy. 1994. *Stream Channel Reference Sites: An Illustrated Guide to Field Technique. General Technical Report RM-245.* United States Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Leopold, L. B., M.G. Wolman and J.P. Miller. 1964. Fluvial Processes in Geomorphology. Freeman, San Francisco, CA.

Wolman, M.G. 1954. *A Method of Sampling Coarse River-Bed Material.* Transactions of the American Geophysical Union, 35: 951-956.

# APPENDIX A

# SITE PHOTOGRAPHS


Photo ID 1 – Station 0+45, facing upstream, July 2004


Photo ID 2 – Station 0+45, facing downstream, July 2004

Photo ID 3 – Station 0+45, right bank, July 2004

Photo ID 4 – Station 0+45, left bank, July 2004

Photo ID 5 – Station 3+35, facing upstream, July 2004
Note:  American Beech down across channel

Photo ID 6 – Station 3+35, facing downstream, July 2004

Photo ID 7 – Station 3+35, right bank, July 2004

Photo ID 8 – Station 3+35, left bank, July 2004


Photo ID 9 – Station 4+45, facing upstream, July 2004


Photo ID 10 – Station 4+45, facing downstream, July 2004

Photo ID 11 – Station 4+45, right bank, July 2004

Photo ID 12 – Station 4+45, left bank, July 2004
Note:  Exposed existing bank


Photo ID 13 – Station 5+70, facing upstream, July 2004


Photo ID 14 – Station 5+70, Facing downstream, July 2004


Photo ID 15 – Station 5+70, right bank, July 2004


Photo ID 16 – Station 5+70, left bank, July 2004

# APPENDIX B

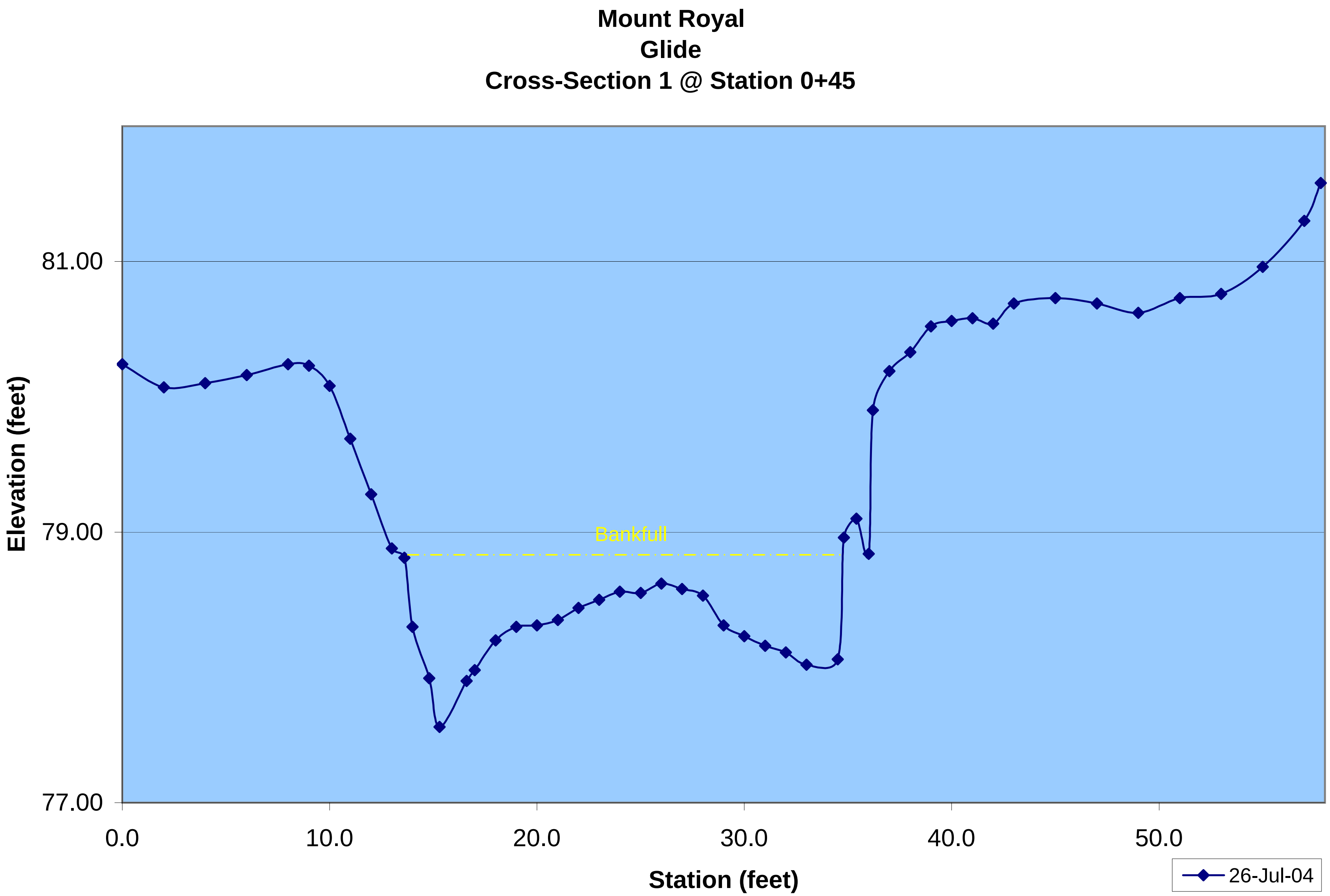
# BASELINE CONDITION TOPOGRAPHIC MAPPING

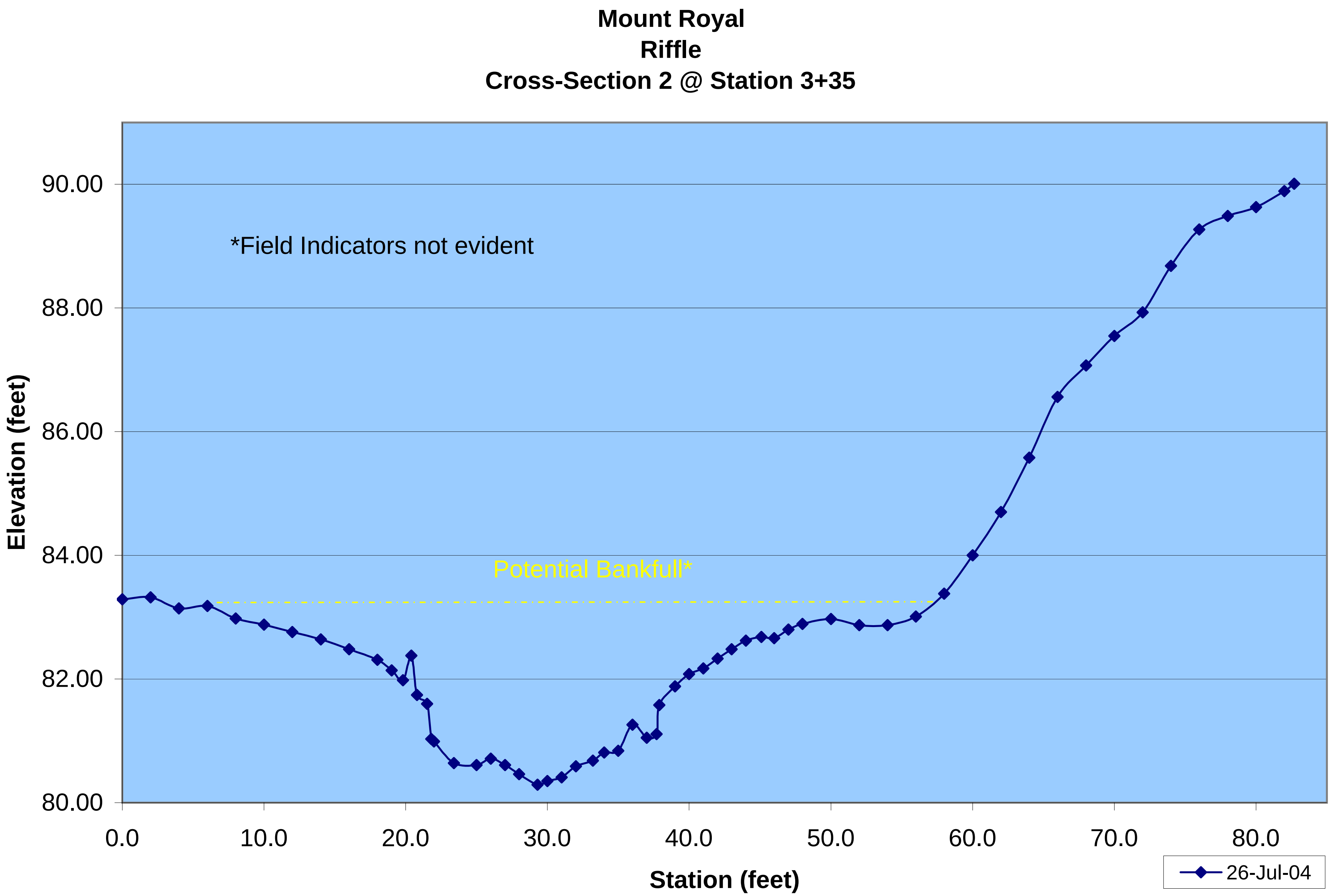
# APPENDIX C

# LONGITUDINAL PROFILE SURVEY DATA

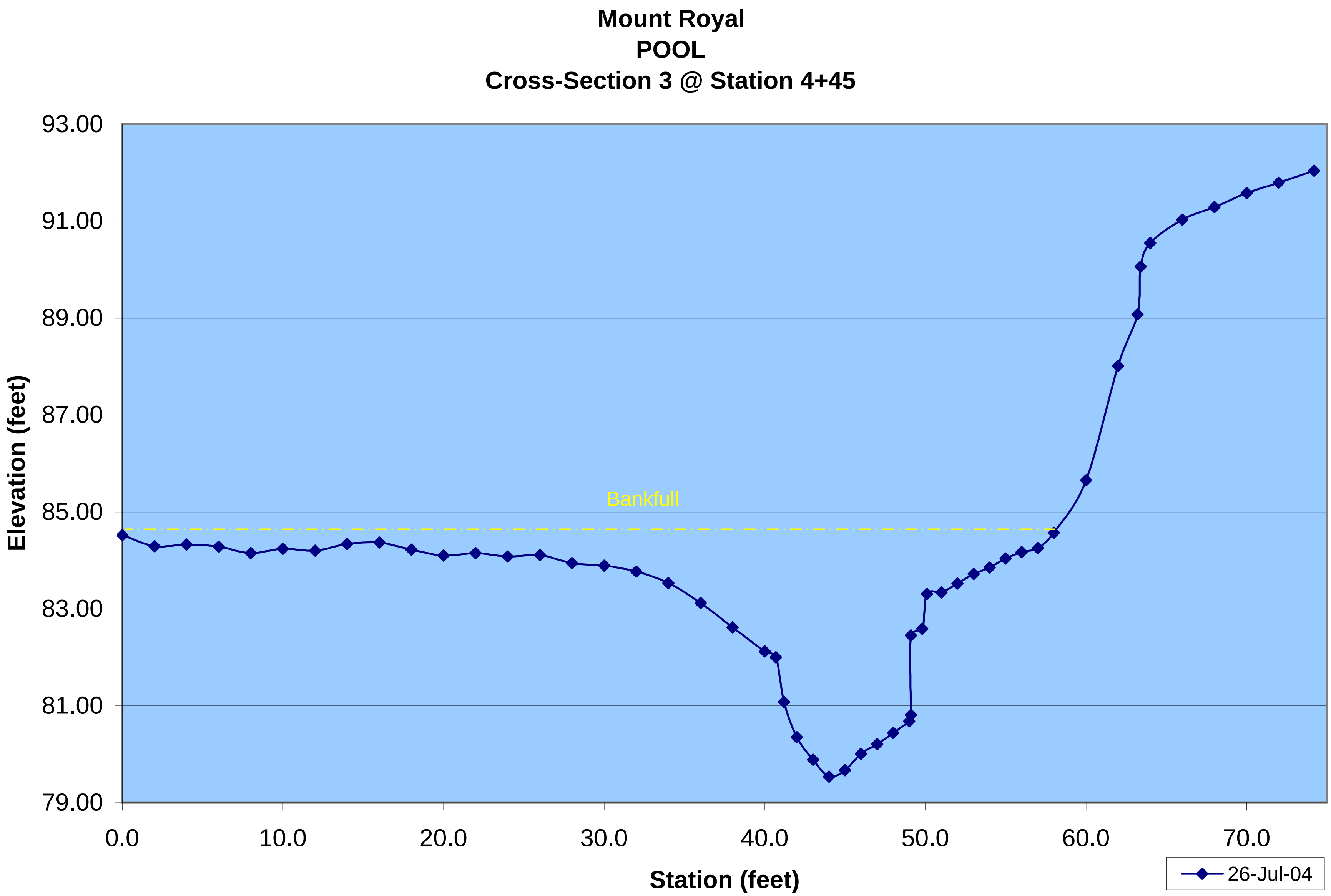
# APPENDIX D

# CROSS-SECTIONAL SURVEY DATA

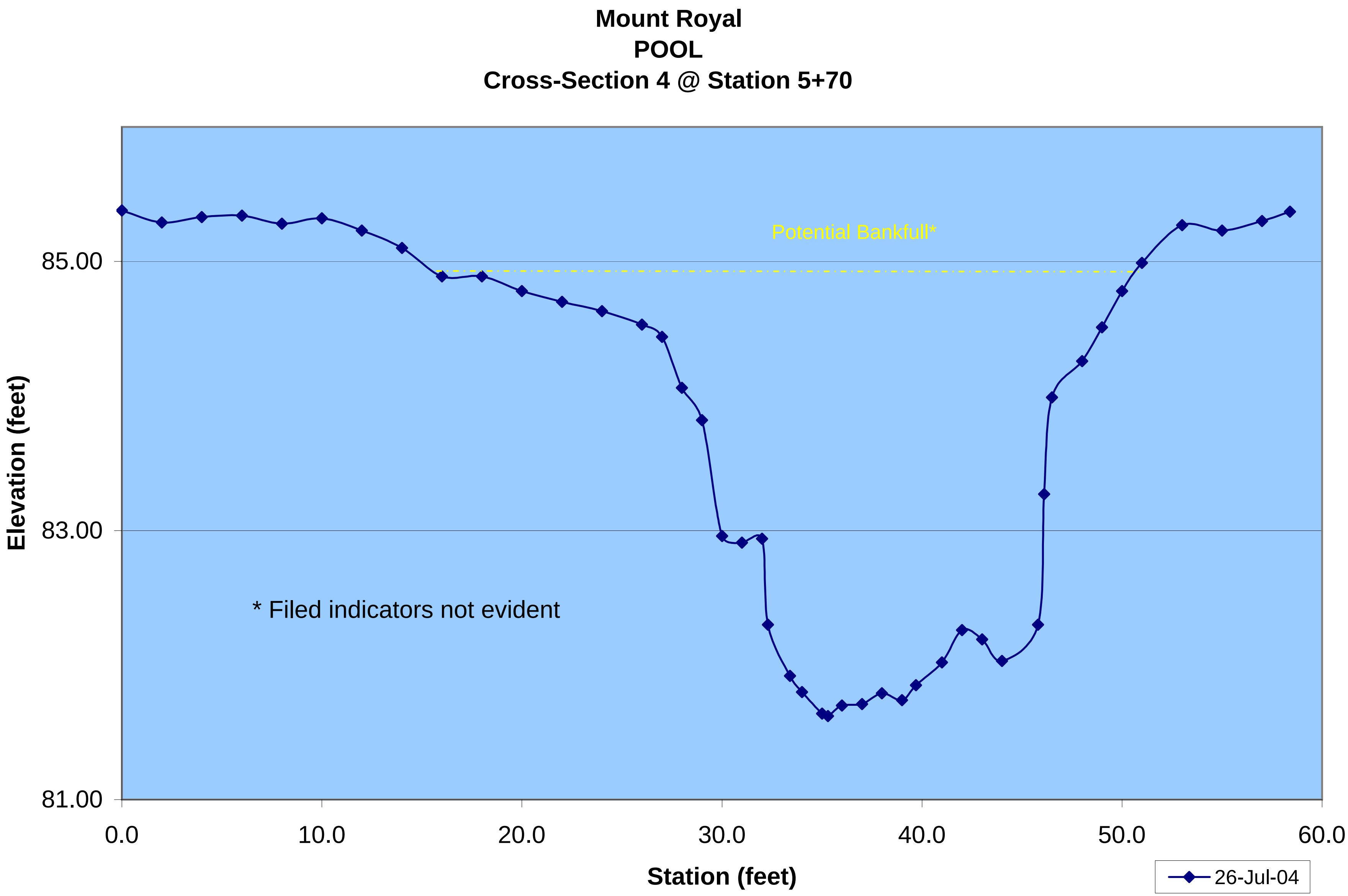

Mount Royal
Glide
Cross-Section 1 @ Station 0+45
Elevation (feet)
81.00
79.00
77.00
Bankfull
0.0
10.0
20.0
30.0
40.0
50.0
Station (feet)
26-Jul-04



Mount Royal
Riffle
Cross-Section 2 @ Station 3+35
Elevation (feet)
90.00
88.00
86.00
84.00
82.00
80.00
*Field Indicators not evident
Potential Bankfull*
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
Station (feet)
26-Jul-04

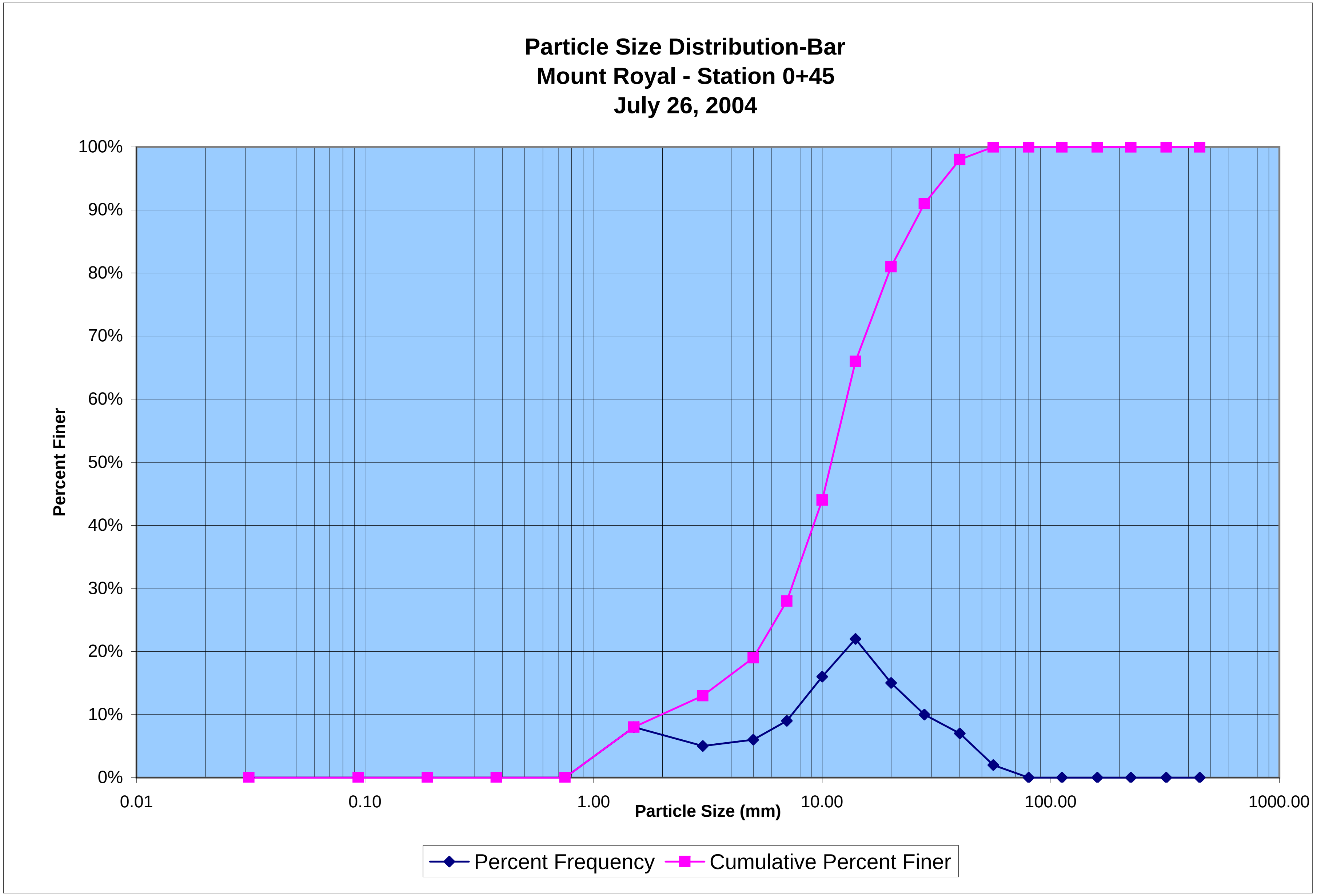


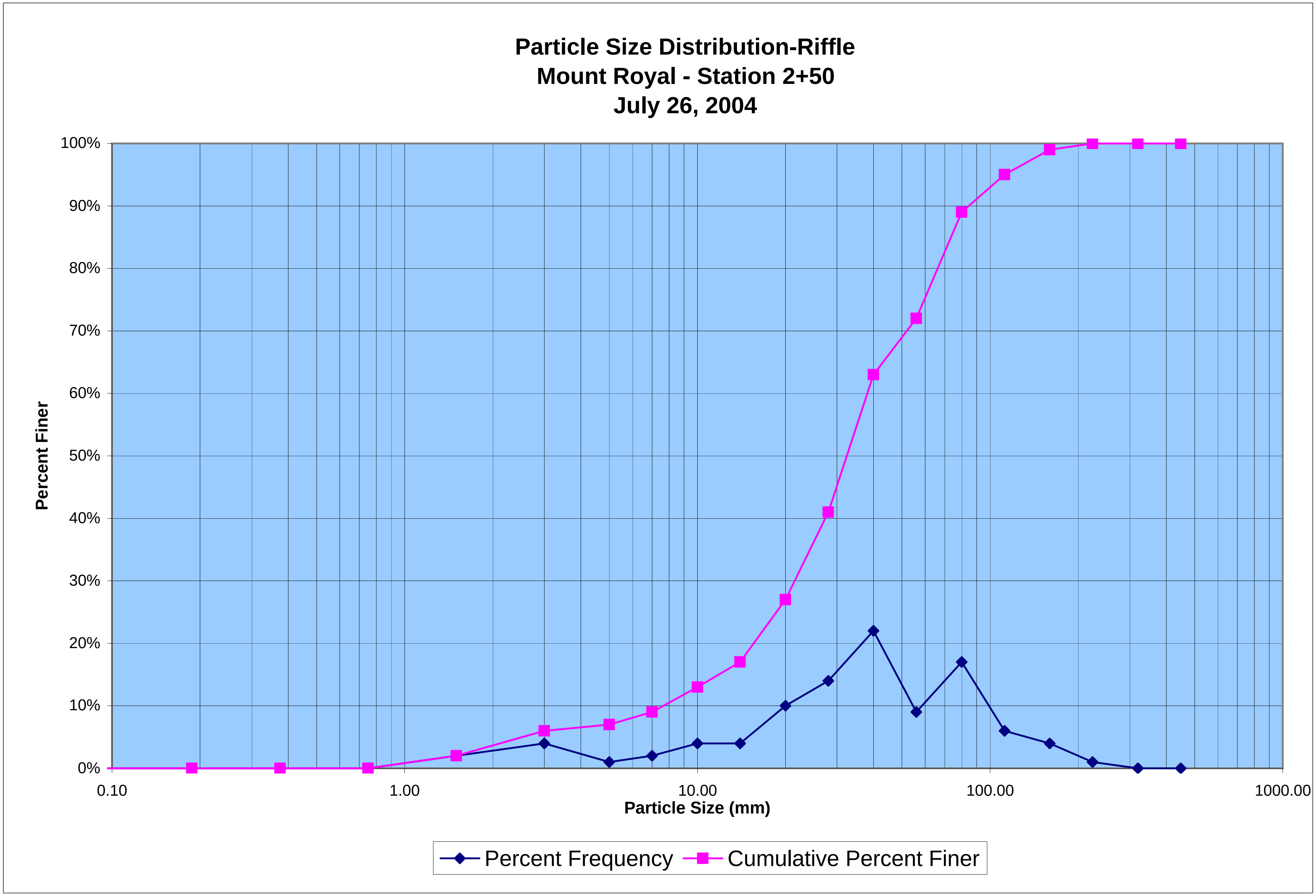
Mount Royal
POOL
Cross-Section 3 @ Station 4+45
93.00
91.00
89.00
87.00
85.00
83.00
81.00
79.00
Elevation (feet)
Bankfull
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
Station (feet)
26-Jul-04


Mount Royal
POOL
Cross-Section 4 @ Station 5+70
Potential Bankfull*
* Filed indicators not evident
Elevation (feet)
85.00
83.00
81.00
0.0
10.0
20.0
30.0
40.0
50.0
60.0
Station (feet)
26-Jul-04

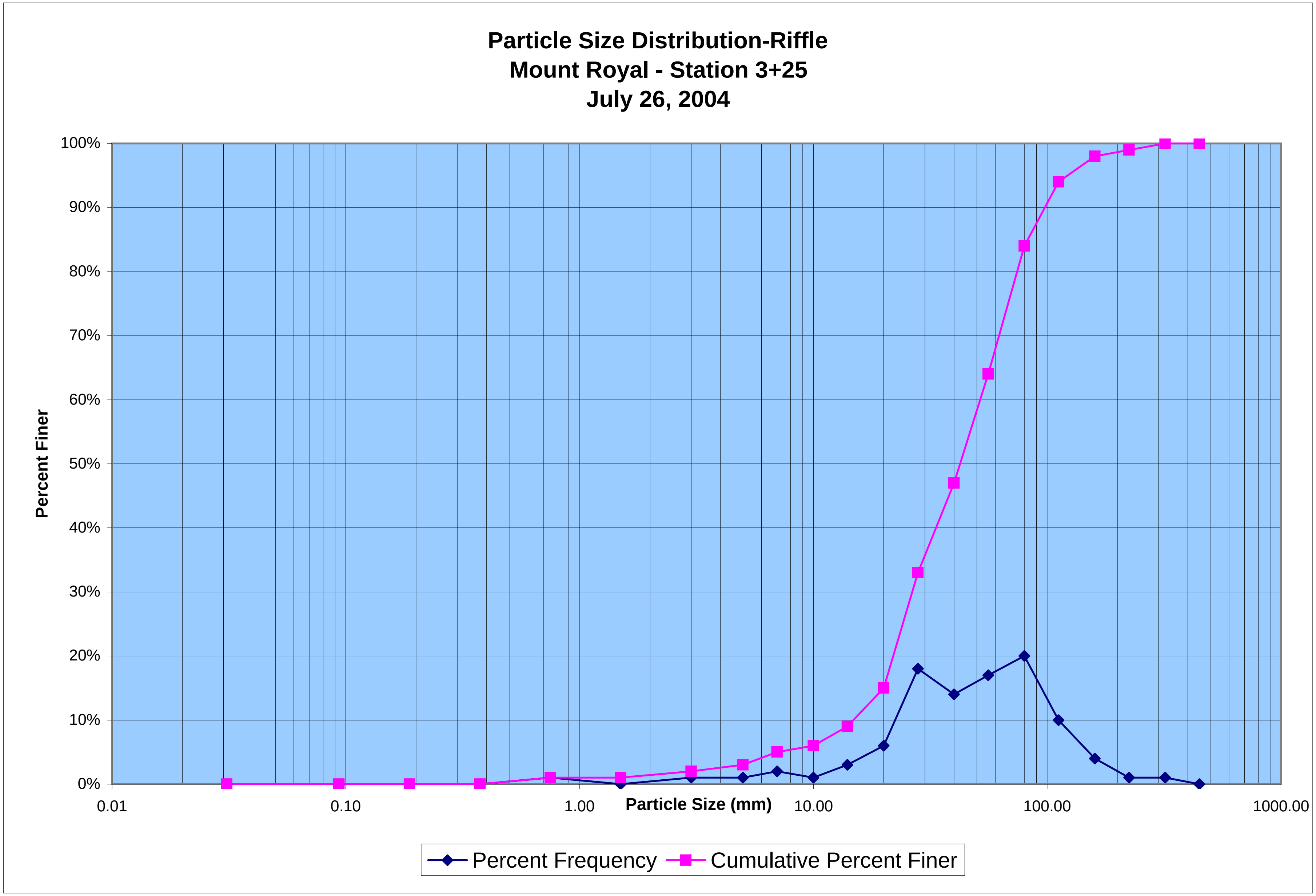
# APPENDIX E

# PEBBLE COUNT DATA


Particle Size Distribution-Bar
Mount Royal - Station 0+45
July 26, 2004
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Finer
0.01
0.10
1.00
10.00
100.00
1000.00
Particle Size (mm)
Percent Frequency
Cumulative Percent Finer



Particle Size Distribution-Riffle
Mount Royal - Station 2+50
July 26, 2004
Percent Finer
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0.10
1.00
10.00
100.00
1000.00
Particle Size (mm)
Percent Frequency
Cumulative Percent Finer



Particle Size Distribution-Riffle
Mount Royal - Station 3+25
July 26, 2004
Percent Finer
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0.01
0.10
1.00
Particle Size (mm)
10.00
100.00
1000.00
Percent Frequency
Cumulative Percent Finer